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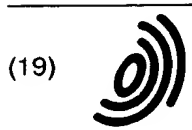
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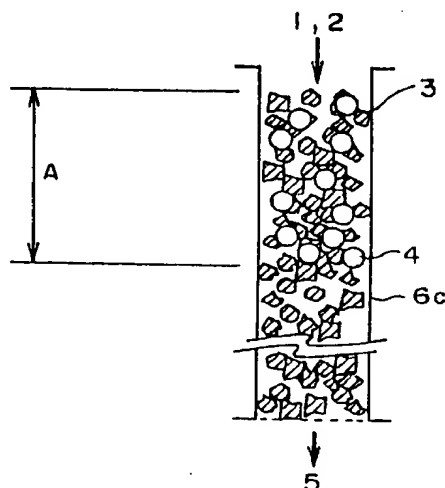
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(54) **PROCESS FOR PRODUCING PHOSGENE**

(57) The present invention provides a process for producing phosgen comprising reacting carbon monoxide with chlorine by passing the both through a catalytic layer which comprises active carbon as a main component and is diluted with a material substantially inert to carbon dioxide and chlorine.

In accordance with the process of the present invention, highly pure phosgen particularly suited for producing polycarbonate by the interfacial polycondensation can be produced.

FIG. 3



EP 0 796 819 A1

Description

TECHNICAL FIELD

5 The present invention relates to a process for producing phosgen from carbon monoxide and chlorine by using active carbon as the catalyst. More particularly, the present invention relates to a process for producing highly pure phosgen which enables suppressing formation of impurities accompanied with the rapid exothermal reaction which takes place when active carbon is used as the catalyst for the reaction of carbon monoxide with chlorine.

BACKGROUND ART

Phosgen is known as an important raw material for chemical synthesis. Particularly because phosgen is an important raw material for polycarbonates, highly pure phosgen is required.

15 Heretofore, phosgen has generally been produced from carbon monoxide and chlorine by using active carbon as the catalyst. However, this process has various problems, such as formation of byproducts and low efficiency of production, which are described in the following.

(1) It is known that, when commercial active carbon is used without treatment as the catalyst for the reaction of carbon monoxide with chlorine, a large amount of impurities, particularly carbon tetrachloride, is formed in the obtained reaction gas as byproducts because of impurities in the active carbon (Japanese Patent Publication Hei-
20 sei 6(1994)-29129) or because of increase in the reaction temperature generally caused by the rapid reaction (Japanese Patent Publication Showa 55(1980)-14044). The obtained product is not satisfactory as a raw material for chemical synthesis in the field where highly pure phosgen is required.

(2) It is generally understood that metal impurities contained in commercial active carbon accelerate the formation of byproducts, such as carbon tetrachloride, in the reaction of carbon monoxide with chlorine. Decreasing the content of such metal impurities to a specific value or lower by washing the catalyst with an acid is considered to be effective for solving the problem (Japanese Patent Publication Heisei 6(1994)-29129). However, when the amount of production is large, treating a large amount of the catalyst in such a manner is troublesome. Therefore, using this treatment in the actual production is difficult, and moreover, efficient removal of the impurities is also difficult. Thus,
30 this treatment is not satisfactory, either.

(3) In order to prevent the increase in the reaction temperature, a process in which the raw materials for the reaction and gases are passed through the surface layer of the catalyst alone and a process in which cooling tubes are arranged in multi-stages have been proposed. However, these processes has a drawback in that the volume efficiency of the reactor is extremely decreased. In the latter process, it is inevitable that the structure of the reactor becomes complicated.
35

(4) A process in which the catalytic layer is cooled from the outside is also described (Kirk-Othmer, "Encyclopedia of Chemical Technology", Second Edition, Volume 5). However, it is known that the central part of the catalyst is heated to a high temperature in this process, and a large amount of carbon tetrachloride is formed.

40 When phosgen contains impurities such as carbon tetrachloride, the impurities are considered to affect the quality of formed polymers in chemical reactions, particularly in the production of polycarbonates by the interfacial polycondensation. Thus, development of a process for producing highly pure phosgen has been desired.

Accordingly, the present invention has the object of providing a process for producing phosgen which enables producing highly pure phosgen suited for chemical reactions, particularly for producing polycarbonates by the interfacial polycondensation, does not require a process for pretreatment of active carbon, a reactor equipped with a specific cooling tube, or a specific mode of flow of the reacting gases, and can efficiently produce phosgen.
45

DISCLOSURE OF THE INVENTION

50 As the result of extensive studies conducted by the present inventors to solve the above problems, it was discovered that highly pure phosgen can effectively be produced by adding and dispersing an inert material into the catalytic layer containing active carbon to dilute the active carbon in the catalytic layer, and that highly pure phosgen can be produced more efficiently by using a specific inert material in a specific form. The present invention has been completed on the basis of the discoveries.

55 Accordingly, the present invention provides:

(1) A process for producing phosgen comprising reacting carbon monoxide with chlorine by passing the both through a catalytic layer which comprises active carbon as a main component and is diluted with a material substantially inert to carbon dioxide and chlorine;

(2) A process for producing phosgen described in (1) wherein the material substantially inert to carbon dioxide and chlorine is a ceramic material and/or a metal material;

(3) A process for producing phosgen described in (2) wherein the ceramic material and/or the metal material is a material formed to a shape of hollow spheres or tubes;

(4) A process for producing phosgen described in (1) wherein the catalytic layer contains 5 to 90 % by volume of the material substantially inert to carbon dioxide and chlorine;

(5) A process for producing phosgen described in (1) wherein carbon monoxide is reacted with chlorine by using a tubular reactor of a multi-tube type; and

(6) A process for producing phosgen according to Claim 5 wherein the catalytic layer which is diluted with a material substantially inert to carbon monoxide and chlorine is used in an introducing part of the tubular reactor.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a schematic diagram exhibiting the process for producing phosgen of the present invention. Figure 2 shows a longitudinal sectional view of a reactor of a multi-tube type for producing phosgen. Figure 3 shows a partially sectional view of a reaction tube in the reactor. In the figures, the numbers and the character have the meanings as listed in the following:

- 1: CO used as a raw material gas
- 2: Cl_2 used as a raw material gas
- 3: a catalyst
- 4: a diluent
- 5: phosgen
- 6: a reactor for producing phosgen
- 6a: an inlet of the reactor for producing phosgen
- 6b: an outlet of the reactor for producing phosgen
- 6c: a reaction tube
- 6d: a jacket for passing cooling water
- 6e: an inlet for cooling water
- 6f: an outlet for cooling water
- A: a diluted part of the catalyst

THE MOST PREFERRED EMBODIMENT TO CARRY OUT THE INVENTION

Figure 1 shows a schematic diagram exhibiting the process for producing phosgen of the present invention. The raw material gases CO (1) and Cl_2 (2) are introduced through an inlet (6a) into a reactor (6) which is packed with a packing material prepared by mixing active carbon (3) used as the catalyst and ceramic balls or diluting materials of stainless steel as the diluent (4). The reaction product COCl_2 is discharged through an outlet (6b) of the reactor (6).

Carbon monoxide and chlorine used as the raw materials for producing phosgen in the present invention are each required to have a high purity.

When carbon monoxide contains hydrogen, hydrogen reacts with chlorine, another raw material for producing phosgen, to form hydrochloric acid. When carbon monoxide contains water, there is the possibility that the produced phosgen is hydrolyzed by the reaction with water to form carbon dioxide gas and hydrochloric acid. When chlorine contains hydrocarbons as impurities, hydrochloric acid and corresponding chlorinated hydrocarbons tend to be formed. Because these compounds are very active with respect to the adsorption to the active carbon used as the catalyst in the present invention, these compounds work as catalyst poisons. Therefore, the presence of these compounds is not preferable. When sulfides are present in chlorine used as the raw material, sulfur chloride is formed. Therefore, it is necessary that sulfides be removed in advance as much as possible. When oxygen is present, the reaction of producing phosgen is adversely affected, and the presence of oxygen is not preferable, either.

As the process for producing carbon monoxide which is used as one of the raw materials in the present invention, various processes have been known. A synthetic gas, a gas from a carbide furnace, a gas from a blast furnace, or a gas from a steel making furnace can be used. These gases are generally supplied for the reaction after purification by passing through an adsorption tower or by cryogenic separation because a high purity gas is required as described above.

As the process for producing chlorine which is used as another raw material, chlorine formed by the electrolysis (such as the diaphragm process and the ion exchange membrane process) of an aqueous solution of sodium chloride can be purified and used.

Active carbon used as the catalyst in the present invention is not limited to a specific type. Typical examples of active carbon are listed in the following with respect to specific features.

- (1) With respect to the form: active carbons of a powder form and active carbons of granules (pellets and tablets).
- (2) With respect to the material used for preparation: active carbons prepared from wood, saw dust, coconut husk, lignin, lignite, brown coal, peat, and coal.
- (3) With respect to the treatment for preparation: active carbons prepared by a pretreatment, such as the steam activation and the chemical activation.

The diluent for the catalytic layer of the present invention is used for decreasing the concentration of the catalyst component in the catalytic layer to prevent concentration of heat generated by the reaction.

The diluent must be a material which is inert to carbon monoxide and chlorine used as the raw materials. When the diluent itself is reactive to carbon monoxide or chlorine, it is difficult that the object of the present invention is achieved. When the diluent has a positive or negative catalytic activity to the reaction of carbon monoxide and chlorine, the object of the present invention cannot be achieved, either. When impurities are contained in the diluent used in the present invention, the impurities are also required to be inert.

Examples of the diluent used in the present invention for the catalytic layer containing active carbon are listed in the following with respect to specific features.

- (1) With respect to the material used for preparation: ceramics and metals which are substantially inert to the raw material gases. Examples of such ceramics and metals include:

- (2) Ceramics: ceramics prepared from alumina, zirconia, magnesium oxide, chromium oxide, silicon carbide, and zinc sulfide; and

- (3) Metals: noble metals as elements and alloys such as stainless steel, hastelloy, and inconel; metals are generally preferable for decreasing temperature because of higher thermal conductivities.

- (4) With respect to the shape: easily available spherical shapes which can easily be mixed with active carbon;

Hollow spheres having a density close to that of the active carbon so that separation or uneven distribution is not caused during mixing with the catalyst and packing into the reactor; and

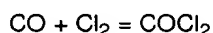
Rings or tubes having a structure not causing separation or uneven distribution during mixing with the catalyst and packing into the reactor and used in packed columns for increasing the contact between a fluid and the packed material. Examples include Raschig rings, Lessing rings, TERALLET, and Pallrings.

- (5) With respect to the size: a diameter and a length both of about 0.1 to 10 mm.

When the size is smaller than 0.1 mm or larger than 10 mm, uniform and stable dispersion in active carbon becomes difficult. Therefore, formation of hot spots and uneven flow of fluids in the catalytic layer tend to be caused.

The condition of the reaction of carbon monoxide with chlorine using the active carbon as the catalyst in accordance with the process of the present invention is described in the following.

The reaction of carbon monoxide with chlorine is generally known to proceed in accordance with the equation:



The temperature and the pressure can be selected in accordance with conventional processes.

It is generally preferable that carbon monoxide is used in an amount by mol which is the same as or slightly more than that of chlorine.

It is most preferable that the whole catalytic layer (active carbon) is diluted in accordance with the process of the present invention. When an exothermic reaction is carried out in a tubular reactor as is the case in the production of phosgen by the reaction of carbon monoxide with chlorine, it is known that a rapid increase in the temperature takes place in the first half of the reactor (for example, "Guide to the design of chemical plants", edited by Kagaku Kogakukai (Japanese Association of Chemical Engineering), (1991)). Therefore, at least the catalytic layer in the first half of the reactor or in the part of the reactor for introducing the raw material gases must be diluted. The undesirable increase in the reaction temperature can be prevented by this dilution.

As for the degree of dilution of the catalytic layer of the present invention, the content of the diluent is preferably 5 to 90 % by volume, more preferably 5 to 80 % by volume, of the catalyst layer. When the content is less than 5 % by volume, the effect of decreasing the reaction temperature by dilution is not obtained. When the content is more than 90 % by volume, uniform dilution is difficult. When the content is in the more preferred range, the above effects are enhanced.

As the type of the reactor applied to the process of the present invention, a tubular reactor of a multi-tube type is preferable.

Figure 2 shows a longitudinal sectional view of a tubular reactor of a horizontal multi-tube type. The reactor for pro-

ducing phosgen (6) is equipped with a number of reaction tubes (6c) at the central part in the longitudinal direction and open to the sides of an inlet (6a) and an outlet (6b) of the reactor for producing phosgen. The space between the reaction tubes is used as a jacket (6d) through which cooling water is passed. The cooling water introduced from an inlet for cooling water (6e) is passed through this jacket and discharged from an outlet for cooling water (6f). The cooling water is used for the purpose of removing heat generated in individual reaction tubes as much as possible and as quickly as possible and makes the reaction of carbon monoxide with chlorine to proceed as efficiently as possible.

Each reaction tube (6c) is packed with a mixture of a catalyst (3) comprising active carbon as the main component and a diluent (4). The raw material gases of CO (1) and Cl₂ (2) are introduced through the inlet (6a) of the reactor for producing phosgen, passed through the reaction tubes, and allowed to react with each other in the reaction tubes. The produced phosgen (5) is discharged from the outlet (6b) of the reactor for producing phosgen.

Figure 2 shows an embodiment in which the raw materials CO (1) and Cl₂ (2) are mixed together in advance and then supplied to the reactor. However, what is required is just that the raw materials CO (1) and Cl₂ (2) be supplied to the reactor in a prescribed relative amounts in mol. The raw materials may be supplied separately or as a mixture prepared in advance. The mode of introduction of the raw materials into the reactor for producing phosgen is not particularly limited. The effect of the present invention does not depend on the mode of the introduction of the raw materials.

The inner diameter of the above reaction tube is not particularly limited. The inner diameter is preferably about 3 to 200 mm for achieving uniform packing of the catalyst and the diluent.

The length of the above reaction tube is varied depending on the inner diameter of the reaction tube, the flow rates of the raw materials, and the efficiency of cooling and cannot be specified.

The number of the reaction tube is varied depending on the amount of phosgen to be produced and cannot be specified.

As the reaction tube, a reaction tube of a vertical type is preferable to that of a horizontal type in view of the easiness of the packing operation of the catalyst and the like into the tube.

For the material of the reactor for producing phosgen, particularly for the material of the inner wall of the reaction tube, the resistance to CO (1) and the resistance to Cl₂ (2) are both required, and glass or stainless steel is preferably used as the material.

Figure 3 shows a partially sectional view of the reaction tube in a reactor of a vertical type. The condition of distribution of the catalyst (3) and the diluent (4) packed into the reactor is schematically shown. The raw materials (1) and (2) are supplied from the inlet at the upper part. The dilution of the catalyst is made mainly at the introducing part of the reactor where the temperature is considered to become high. (The area A in Figure 3 shows the diluted area and can be referred to as a diluted part of the catalyst.)

A single diluted part of the catalyst exhibits a sufficient effect. However, two or more diluted parts may be formed when the design of the size of the reactor requires them.

The present invention is described in more detail with reference to examples in the following. However, the present invention is not limited by the examples.

Example 1

The reactor for producing phosgen (6) shown in Figure 2 was used in a vertical mode. A reaction tube made of stainless steel and having a length of 4 m and an inner diameter of 15 mm was packed with a commercial granular active carbon (active carbon made from husk of coconut and pulverized to a diameter of 1.2 to 2.4 mm). The reaction tube was packed with the active carbon in the following manner: a part of the reaction tube of the length of 1 m from the end for introducing the raw material gases was left unpacked; the remaining part of the length of 3 m was packed with the above active carbon; and then the part of the reaction tube of the length of 1 m which had been left unpacked was packed with a material prepared by mixing the same amounts by volume of ceramic balls made of zirconia (a diameter of 2 mm) and the above active carbon.

Carbon monoxide and chlorine were introduced into the reaction tube from the end containing the diluted catalyst in flow rates of 5.05 mol/hr and 4.80 mol/hr, respectively, and phosgen was produced at a rate of about 500 g/hr.

Ten thermocouples were attached to the reaction tube at positions which are arranged at every 5 cm along the reaction tube starting from the inlet of the raw material gases so that the maximum temperature of the reactor could be measured. The reactor has a double tube structure to form a jacket. Hot water of about 75°C was passed through the jacket, and the heat generated by the reaction was removed.

The results of the reaction were evaluated from the maximum temperature, the distance of the position of the maximum temperature from the inlet of the raw materials gases, the conversion of the reaction obtained by the analysis of the gas after the reaction by the gas chromatography, and the content of impurities in the obtained phosgen.

The condition of packing of the catalytic layer and the results of the reaction are shown in Table 1 and Table 2, respectively.

Examples 2 to 6

Phosgen was produced under the same condition as that in Example 1 except that the type of active carbon in the catalytic layer and the length of packing of the catalytic layer were changed.

The condition of packing of the catalytic layer and the results of the reaction are shown in Table 1 and Table 2, respectively.

Comparative Example 1

Phosgen was produced under the same condition as that in Example 1 except that the reaction tube was packed with active carbon of the catalyst without dilution.

The condition of packing of the catalytic layer and the results of the reaction are shown in Table 1 and Table 2, respectively.

Table 1

	catalytic layer		
	diluent	diluted length (m) ^{*1}	degree of dilution (% by vol.) ^{*2}
Example 1	zirconia (spherical, 2 ϕ)	1	50
Example 2	zirconia (spherical, 2 ϕ)	1	30
Example 3	SUS (spherical, 1.5 ϕ)	1	30
Example 4	SUS (Raschig ring, 1/8")	1	50
Example 5	alumina (spherical, 2 ϕ)	0.5	50
Example 6	alumina (spherical, 2 ϕ)	0.5	80
Comparative Example 1	-	-	-

*1: the distance from the inlet of the raw material gases

*2: the content of a diluent used for dilution in % by volume

Table 2

	reaction temperature		conversion of reaction (%)	impurities in phosgen	
	maximum temperature (°C)	position of measurement (cm) ^{*3}		CHCl ₃ (ppm by wt.)	CCl ₄ (ppm by wt.)
Example 1	250	25	100	35	110
Example 2	260	25	100	40	90
Example 3	230	25	100	60	130
Example 4	235	20	100	45	100
Example 5	245	25	100	50	100
Example 6	275	25	100	80	180
Comparative Example 1	460	15	100	250	420

*3: the distance from the inlet of the raw material gases

INDUSTRIAL APPLICABILITY

As described above, in accordance with the process of the present invention, the reaction temperature is significantly decreased and the content of impurities in the produced phosgen can be decreased to an extremely small value by diluting the catalytic layer containing active carbon as the main component, particularly the catalytic layer at the introducing part of the raw material gases, with a diluent. The process is highly valuable for industrial application.

Claims

1. A process for producing phosgen comprising reacting carbon monoxide with chlorine by passing the both through a catalytic layer which comprises active carbon as a main component and is diluted with a material substantially inert to carbon dioxide and chlorine.
2. A process for producing phosgen according to Claim 1 wherein the material substantially inert to carbon dioxide and chlorine is a ceramic material and/or a metal material.
3. A process for producing phosgen according to Claim 2 wherein the ceramic material and/or the metal material is a material formed to a shape of hollow spheres or tubes.
4. A process for producing phosgen according to Claim 1 wherein the catalytic layer contains 5 to 90 % by volume of the material substantially inert to carbon dioxide and chlorine.
5. A process for producing phosgen according to Claim 1 wherein carbon monoxide is reacted with chlorine by using a tubular reactor of a multi-tube type.
6. A process for producing phosgen according to Claim 5 wherein the catalytic layer which is diluted with a material substantially inert to carbon monoxide and chlorine is used in an introducing part of the tubular reactor.

FIG. 1

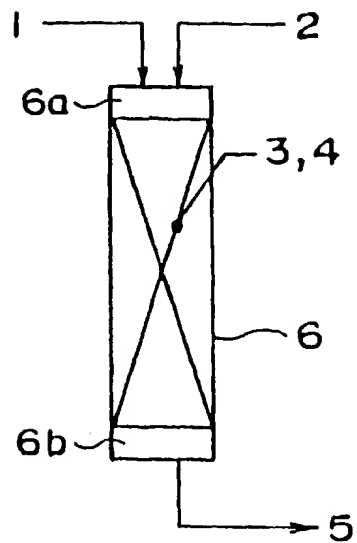


FIG. 2

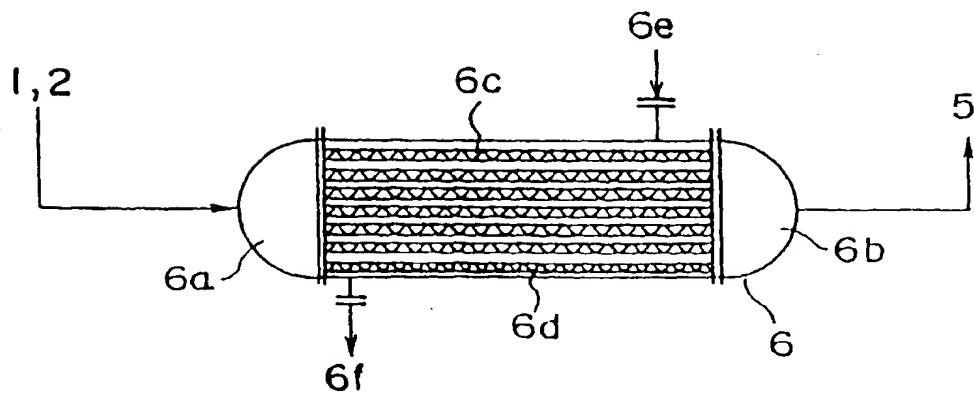
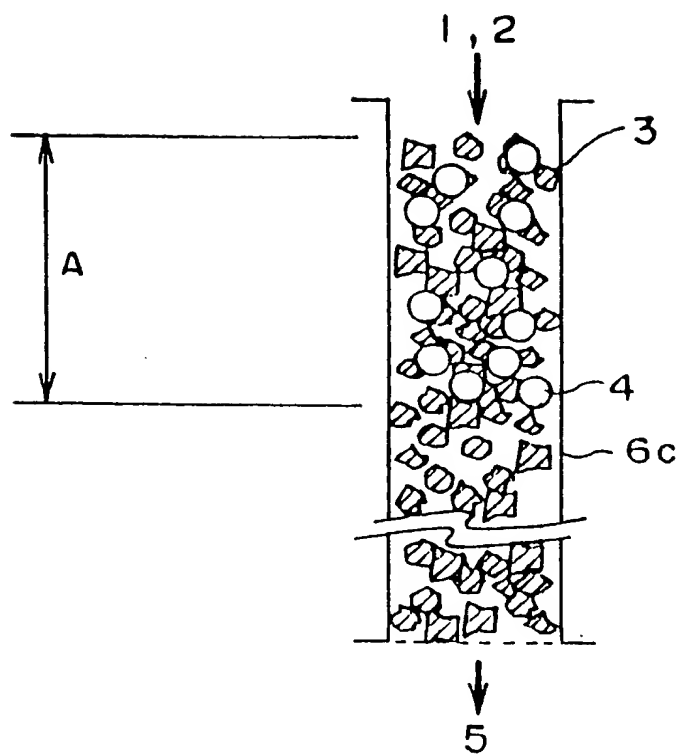


FIG. 3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP95/02421

A. CLASSIFICATION OF SUBJECT MATTER Int. Cl ⁶ C01B31/28 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int. Cl ⁶ C01B31/28, B01J8/02 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1926 - 1995 Kokai Jitsuyo Shinan Koho 1971 - 1995 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CAS ONLINE phosgen (75-44-5/RN), activ, carbon (7440-44-0/RN) carbon monoxide (630-08-0/RN)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, 6-29129, B2 (Idemitsu Petrochemical Co., Ltd.), April 20, 1994 (20. 04. 94), Line 9, left column, page 1 to line 15, left column, page 2 (Family: none)	1, 2, 4, 5, 6
Y	JP, 52-100365, A (Ricoh Co., Ltd.), August 23, 1977 (23. 08. 77) & US, 4179407, A & DE, 2706182, B	1, 2, 4, 5, 6
A	JP, 55-14044, B1 (Mitsubishi Gas Chemical Co., Inc.), April 14, 1980 (14. 04. 80) (Family: none)	1 - 6
Y	JP, 62-1736, U (Mitsubishi Heavy Industries, Ltd.), January 8, 1987 (08. 01. 87), Fig. 2 (Family: none)	5
Y	JP, 45-18703, B1 (Showa Denko K.K.), June 26, 1970 (26. 06. 70),	5
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search February 7, 1996 (07. 02. 96)		Date of mailing of the international search report February 27, 1996 (27. 02. 96)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.		Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP95/02421

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Lines 29 to 33, left column, page 1, Fig. 1 (Family: none)	
Y	JP, 61-161133, A (Mitsubishi Heavy Industries, Ltd.), July 21, 1986 (21. 07. 86), Claim (Family: none)	6
A	JP, 63-58696, U (Nishihara Kankyo Eisei Kenkyusho K.K. and another), April 19, 1988 (19. 04. 88), Claim (Family: none)	3
A	JP, 52-53768, A (Toshiba Machine Co., Ltd.), April 30, 1977 (30. 04. 77), Fig. 1 (Family: none)	3

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